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Original research article

Dynamics of policy change and intermediation: The arduous transition towards low-energy homes in the United Kingdom

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ABSTRACT

The transition towards low-energy buildings in the United Kingdom is challenging. Several policy changes have affected the actions and agency of actors. Drawing on the sustainability transitions literature, we analyse the development of the low-energy homes niche, focusing on the dynamics between intermediary organisations and policy development for low-energy homes. Based on rich interview and secondary data, we note how the existence and activities of transition intermediaries are enabled or curtailed by policy changes. We identify niche development phases along with the position and activities of intermediary organisations. In the predevelopment phase, non-state transition intermediaries have formed when government policy has been weak or market-based. During take-off, targeted policy initiatives have created protective spaces and stimulated the emergence of new intermediaries aiming to consolidate the niche. State-affiliated intermediaries have been established as part of active energy efficiency policy, but later ceased to exist or became privatised. Existing organisations have adopted intermediary functions to advance low-energy homes in response to policy. Furthermore, intermediaries have on occasion influenced policy development, often through cooperation among an ecology of intermediaries. In conclusion, we raise questions regarding intermediaries in the changing governance context.

1. Introduction

International oil crises of the 1970s led to official building energy efficiency policy in many countries, paving a way towards low-energy buildings. Yet, the existing building stock still today contributes a significant share of carbon dioxide emissions globally, and the transition to low-energy buildings has not progressed very far.

The field is abound with barriers for the adoption of system innovations that would significantly reduce energy demand from buildings [1,[2]]. Despite new strategies to overcome barriers [2] and the long-established sustainable buildings niche [3,4], the UK transition (largely dependent on energy efficiency policy to stimulate change) is very slow.

We focus on the development towards low-energy residential buildings (from here on referred to as 'low-energy homes')[1] in the United Kingdom (UK). UK is a country with an active climate policy community involving central government actors, policy makers and non-governmental organisations [5]. A considerable sustainable housing movement has developed in the last 30–40 years, promoting concepts such as 'autonomous homes', 'eco-homes', 'sustainable homes', 'low-carbon homes' and 'passive houses' (e.g. [6,7]). While this movement has pioneered new ideas and practices, many of their innovations have not diffused widely [4]. This movement forms a backdrop to today's low-energy homes niche in the UK.

Empirically, the low-energy homes niche consists of different strands and conceptualisations as noted above. Over time, it has branched into new directions (cf. [8]). Yet, the developments can be seen to form a broader low-energy homes niche due to the niche actors' similar aims to break free from the existing set of building rules, the interrelations between the actors across new and existing buildings, and the build-up of activities benefitting policy development.

During the last four decades, intermediary organisations have formed to advance innovative projects, create a protective space for their diffusion, and to lobby or implement new policies for low-energy homes. We explore the dynamics of such 'transition intermediaries' operating to advance sustainable sociotechnical change through policy development.

Transition intermediaries serve systemic functions, including the facilitation of multi-actor innovation networks, linking demand and supply side for disruptive innovation, and connecting niche innovators

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[1] Low-energy homes are defined here as new buildings designed to use minimum energy, or existing buildings undergone whole house energy retrofit.

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to financial and human resources [9]. Such intermediaries may influence transitions by "*disturbing existing structures, practices and behaviours*", through actively facilitating niche development and/or through aiming to destabilise the dominant technological, institutional and market regimes ([10]: 1371).

We aim to fill a gap in the transitions literature regarding how the emergence and activities of transition intermediaries link to national policy change. Rather than focusing on specific intermediary actors, we trace the low-energy homes niche and policy development in the UK, identifying how multiple intermediaries across the new build and retrofit sectors change and interact with policy over time.

We also aim to unwrap the concept of 'dynamic ecology of intermediaries' [11] empirically in the context of niche and policy development. Kivimaa et al. ([9]: 5) described an 'ecology of intermediaries' as specific intermediaries having differing competences, remits, and operational models that "*complement but also compete with each other, forming interdependencies and overlaps, sometimes also leaving gaps vis-à-vis a given innovation process or system*".

Empirically, we explore:

- When and why, during niche development, have new intermediary organisations emerged or existing organisations subsumed roles for low-energy homes vis-à-vis policy change?
- How has this 'ecology of intermediaries' changed over time?
- How have the intermediary organisations influenced policy development for low-energy homes?

A backdrop for this analysis is the development of UK low-energy homes policy for new and existing building stock. New build was influenced by a zero-carbon homes agenda taking-off from 2006 onwards and slowing down from 2009, involving a complete policy overhaul in 2015.

We draw on theoretical concepts from the sustainability transitions literature, including phases of transitions [12,13] and niche development [8,14]. We present novel empirical insights, and note how policy change can enable or curtail a dynamic ecology of intermediaries. Our study also shows, importantly, that niche development does not necessarily scale-up but may also weaken after take-off.

We draw on 29 interviews conducted during 2014–2018 and use academic and grey literature to build a description of the UK low-energy homes niche and related policy development during 1970–2016.

Section 2 introduces the theoretical concepts informing our analysis. Section 3 describes the methods. Section 4 starts by focussing on how different policy phases form sub-phases in the broader phases of niche development for low-energy homes, providing a brief historical description. It then moves onto a novel analysis pertaining to the emergence of intermediary organisations, their changing roles and their influence on the policies supporting niche development. Section 5 discusses and concludes.

2. Conceptual setting: niches, phases and intermediaries in transitions

2.1. Niche development

Niches are spaces where networks of actors experiment with more environmentally sustainable organisational forms and technologies [6]. While a niche originally forms around a specific (often technological) innovation, a process of niche branching can follow, containing subsequent niches, e.g., new application domains, formation of market niches, or niche replication [8]. White and Stirling ([15]: 839) note that "'*niche' is not objectively empirically fixed in any given setting, but depends heuristically on the purpose and level of analysis*".

Multiple projects are seen to form a technological trajectory, and produce generic lessons and shared cognitive rules through dedicated aggregation activities [16]. Actors sharing similar aims coalesce and construct narratives to draw attention and material resources for advancing the niche [17]. Intermediary actors may become crucial in aggregating lessons, connecting actors and forming narratives. Niches can be protected through support from suppliers, users and public policy, the latter including, for example, subsidies and favourable treatment in legal frameworks [17].

Prevailing socio-technical regimes consist of dominating technologies, institutions, practices and cultural norms [18], 'against' which niches have to perform [19]. Overarching, long-term landscape developments, e.g., political trends, environmental changes or wars [18] create pressure on regimes, providing opportunities for new niches [14].

2.2. Phases of transitions and niche development

The literature describes phases of transitions as predevelopment and exploration, take-off, acceleration, and stabilisation [12,13]. As these are broad for analysing the intricacies of niche development, we also draw on niche development studies. Rotmans et al. [12] describe how the concept of 'transition' can be applied at different levels of aggregation (companies, sectors, countries, regions), developments of which can be followed over time and compared to each other.

The *predevelopment* phase is depicted as a dynamic equilibrium, where no visible changes can be observed to status quo [12], and it involves small-scale, temporary experimentation [13]. Rotmans et al. [12] note that transitions may appear fast even when the predevelopment phase is long, and the take-off phase remains largely unnoticed.

Yet, *take-off* is more visible [12], illustrated by the build-up of novel solutions [13]. During take-off, niche development advances from individual experiments to strategic actions that aggregate experiments, build agendas and create temporary protective spaces for the niche; partly enabled by policies such as R&D or deployment support schemes [20]. During take-off, the niche is expected to face significant opposition from regime actors.

In both predevelopment and take-off phases, niches benefit from *shielding* processes (e.g. the creation of support and funding schemes) that create protected space away from mainstream selection environments [20]. In both phases, *nurturing* also takes place, consisting of three processes: *articulation of expectations and visions* by piloting new concepts, lobbying for change, and creating new standards; *creating a space for learning* by providing education, advice and aggregated knowledge from experiments; and *connecting actors* by creating networks and pooling resources [20].

In the *acceleration* phase, niches become more established, and the developed technological or social innovations diffuse more widely, starting to compete in mainstream markets and with the incumbent regime [21]. The niche becomes competitive within mainstream socio-technical practices (fit-and-conform) or is coupled with institutional reforms and re-structured regimes that make the mainstream market favourable to niche innovations (stretch-and-transform) [20]. Structural changes become noticeable through a build-up of socio-cultural, economic, ecological and institutional modifications [12,13].

In the stabilisation phase, a former niche has become the new regime [21].

Safarzynska et al. [13] note how the notion of a multi-phase transitions directs attention into the timing of (policy) interventions to steer transitions. They draw on an example from Zundel et al. [86] how during stabilisation and early predevelopment, investments into a diversity of promising solutions would be useful to increase the scope of learning. In later transition phases, if the transition path is unstable, implementation of destabilising policies, such as environmental taxes or tradable permits and withdrawing political support for old technological solutions may be needed [13]. Yet, such 'unlocking' of policies does not happen self-evidently and can be extremely difficult [13,87].

2.3. Transition intermediaries

An emerging literature on transition intermediaries, originated by van Lente et al. [22] and Geels and Deuten [23], focuses on actors (and platforms) that intermediate between production and consumption, learning and its utilisation, and/or a range of other actors with the intention to facilitate and speed-up sustainability transitions. Empirically, the literature describes examples in which such intermediation may occur (a) between actors, e.g., building new networks to support niche development, or (b) between activities, e.g., aggregating experiences and learning from pilot projects to inform policymaking, and connecting processes of learning to the articulation of expectations.

The literature on transition intermediaries has focused on niche development (e.g. [24,15]) and urban transitions (e.g. [25–27]), with less attention paid to the destabilisation of existing regimes [28]. Scholars have examined how specific actors act as intermediaries, and longitudinal analyses regarding multiple intermediaries are rare.

Parag and Janda's ([29]: 104) illustration of intermediary actors fits well for our study: "*formal and informal government and semi-government energy agencies, NGOs, agencies and organisations sponsored by utilities, energy services companies and providers (ESCOs),… local communities, grassroots and networking platforms,… research and technology organisations, chambers of commerce, innovation centers, industry associations and partnerships*". However, we do not perceive all such organisations automatically as intermediaries, but instead make our assessment based on their activities (in this case on advancing transition towards low-energy homes). Kivimaa [10] notes the varying nature of intermediation in organisations by pointing out that not all activities of a specific organisation relate to intermediation, describing intermediary organisations to have a high focus on, or a high proportion of, activities involving intermediation.

While the conceptualisation of knowledge brokers (e.g. [30]) and innovation intermediaries (e.g. [31,11]) apply also to transition intermediaries, the latter take broader systemic roles. For example, knowledge brokers do not extend their activities to strategic visioning and political manoeuvring using the presentation and interaction of different information and evidence [32], which can be regarded a transition intermediary role.

We pay specific attention to intermediary organisations engaged in policymaking processes, e.g. by attempting to influence policy through a lens of transitioning and/or by being established because of policymaking. Drawing inspiration from Moss [33], we examine how intermediary organisations come into being vis-a-vis policy development.

3. Method

We undertook a qualitative case study analysis (cf. [34]) completed during a large research programme in 2014–2018. The development of UK low-energy homes provided an interesting case due to the UK's long history of sustainable housing movements (cf. [4]) and ambitious climate policy objectives. Yet, the number of low-energy homes (existing and new build) has remained small.

We combined in-depth interviews with academic and grey literature to build an understanding of policy development, niche development and intermediary organisations. Twenty-nine stakeholder interviews (16 in person, 13 by phone, all digitally recorded) were completed in three rounds (Table 1). First ten interviews gathered information on policy development, with interviewees chosen based on their expertise regarding low-energy homes policy.

The second set of interviews focused on developments in low-energy homes from the perspective of different organisations with potential to act as intermediary actors. The selection was based on authors' prior knowledge in the field, document and website analysis, and snowballing.

Alongside interviews, we collected information on 75 organisations active in the low-energy homes sector via an internet search and

Table 1
Sequence of interviews, interviewee types and focus.

Interview round	No. of interviews	Type of interviewees	Focus	Timing of interviews
1st	10	I1 NGO, I2 charity, I3 charity, I4 research organisation, I5 charity, I6 campaign, I7 NGO, I8 membership organisation, I9 network organisation, I10 ex-government	UK building energy efficiency policy development	July–September 2014
2nd	12	I11 social enterprise, I12 community organisation, I13 anonymous, I14 social housing fund, I15 charity, I16 research organisation, I17 social enterprise, I18 local administration, I19 social enterprise, I20 local administration, I21 social enterprise, I22 membership organisation	Developments in UK low-energy homes; activities of specific organisations	May 2015–March 2016
3rd	7	I23 membership organisation, I24 network organisation, I25 ex-government, I26 academic-practitioner, I27 network organisation, I28 academic-practitioner, I29 consultancy	Activities and influence of intermediary organisations on policy development	May 2017, February–March 2018

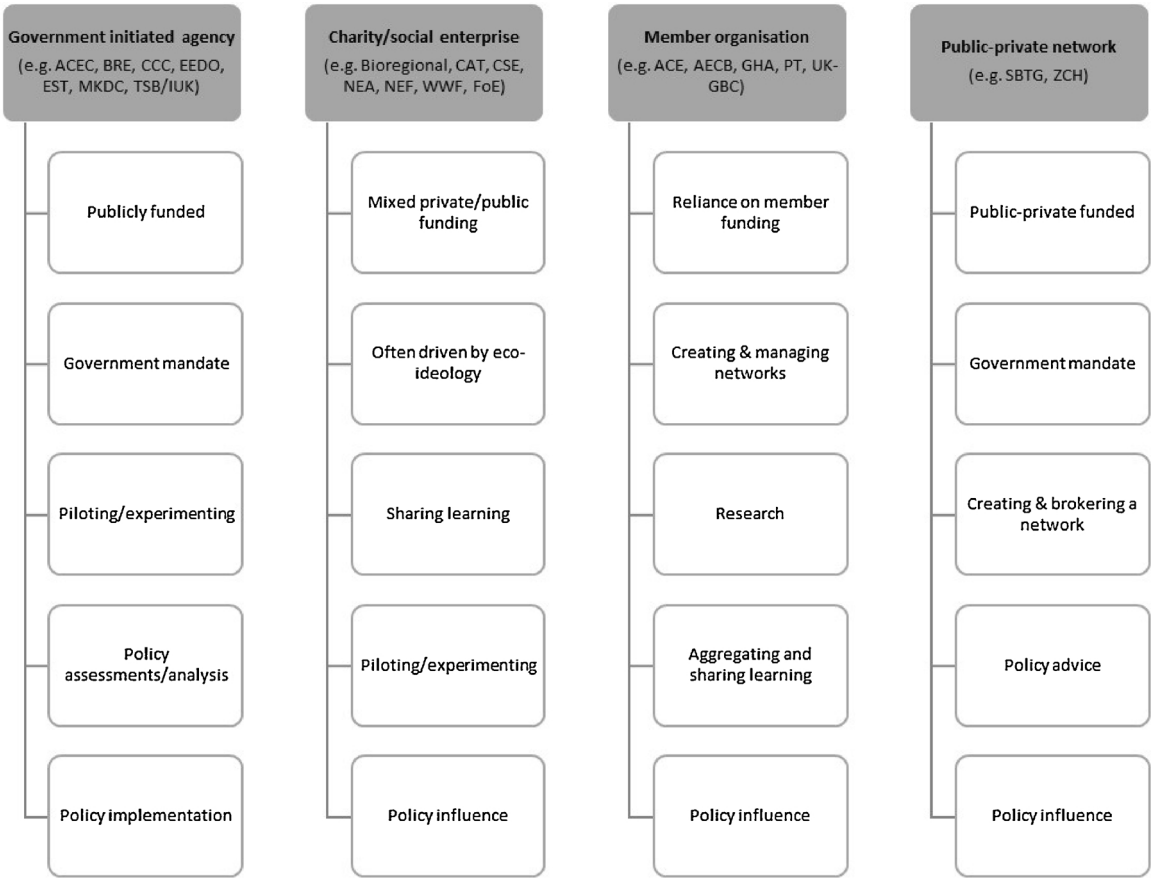

Fig. 1. Intermediary organisations in niche development for low-energy homes.

compiled information on their history, remit and activities, identifying potential intermediaries. Academic and grey literature provided insights on the identified key intermediaries, their emergence and policy influence. Fig. 1 illustrates different types of intermediary organisations operating in the low-energy homes context and their core characteristics.

We created a 15,000-word narrative of the UK low-energy homes niche, highlighting key intermediaries (not all 75 identified) based on the interview and document analysis. Two authors coded the narrative document and identified key phases of niche and policy development in relation to landscape pressures, regime-level policy developments, and the emergence of intermediary actors and their position.

To strengthen our initial findings on intermediaries' influence on policy development, we conducted a third round of interviews in May 2017 and February–March 2018 with long-term experts in the UK low-energy homes sector. We refer to interviews as I1-29 in the following sections.

4. Findings

Section 4.1 presents a summary of 45 years of policy and niche development for low-energy homes. From our initial historical narrative, we identified nine phases related to policy development, which constituted sub-phases to the broader transition phases of predevelopment, take-off and gradual backtracking (see Appendix A). Section 4.2 illustrates our findings regarding the dynamics of intermediary emergence with policy development. Section 4.3 illustrates examples how the intermediaries have influenced policy development.

4.1. Niche-regime development in UK low-energy buildings: a summary of phases

4.1.1. 1970–1998: predevelopment

The first two decades since the first oil crisis in 1973 fall under predevelopment, containing five policy sub-phases:

1 1970–1978: Oil crises, initiation of active energy efficiency policy and pioneers of alternative, sustainable housing emerge
2 1979–1982: Economics of energy and rational choice dominate, but also influence the emergence of new intermediaries for low-energy homes
3 1983–1986: Come back of strong energy efficiency agenda and large-scale pilots
4 1987–1990: Free market and information approach to energy efficiency, and non-state intermediaries lobbying for stronger policy
5 1991–1998: Climate change concerns, mainstreaming energy efficiency in building assessment, and first steps towards passive house and zero-carbon designs

During early predevelopment (1970–1978), emerging policy attention focused on reducing building energy demand. In 1973, significant increases in oil prices led to the creation of the first Department of Energy[2] and a rethink about energy efficiency [35]. Regarding the existing building stock, a 'Save It' energy saving campaign was launched in 1975, and a government run energy efficiency programme in 1977 which included a 10-year insulation programme [36]. In 1976, Part

[2] See Mallaburn and Eyre [36] for details regarding subsequent changes in government departments.

L1A 'Conservation of Fuel and Power in New Dwellings' was introduced to building regulations addressing, for the first time, energy consumption in new buildings [37], and setting a trajectory towards new low-energy homes (I2). The first requirements for energy efficiency in building regulations were modest (I25), but they were regarded as an extremely interventionist government approach [36] and indicated the dire impacts of the oil price shocks on the economy.

Locally, environmentally motivated individuals and groups developing new eco-efficient, solar or autonomous homes emerged (e.g. [3]). Government support for experimentation was incremental and piecemeal.

Early policy activity soon halted through a new Conservative government in 1979, who believed that energy prices were sufficient to reduce demand. This initiated a second sub-phase under predevelopment (1979–1982). New non-state actors emerged with concern about the existing building stock. They piloted and lobbied to continue regulation on energy efficiency.

The third sub-phase (1983–1986) saw the return of energy efficiency policy. In 1983, the Conservative government appointed Peter Walker as Energy Secretary who became a "*political heavyweight champion of energy efficiency*" [35]. "*Over a little more than two years 20,000 people came to energy management meetings hosted by Ministers and senior officials*" ([36]: 26). Walker led the development of energy efficiency policy "*from something quite stagnant to eye-catching*" (I25).

Regional energy efficiency offices and best practice guidelines were established, Part L of the building regulations tightened, and 1986 was announced an 'Energy Efficiency Year' together with a 'Get More for your Monergy' national energy efficiency campaign [36]. Milton Keynes 'garden city'[3] became a research hub for sustainable buildings [38] and 53 innovative low-energy and solar homes developed by 33 companies were displayed [39]. These developments addressed both new build and retrofit.

During a fourth sub-phase (1987–1990), a third Conservative government returned to a free-market based approach, leading to cuts in energy efficiency budgets, demonstration initiatives and subsidies [36]. New actors emerged to promote sustainable construction, deliver low-energy projects for new and existing buildings, and advocate higher energy efficiency standards.

During late predevelopment (1991–1998), the 1994 United Nations Framework Convention on Climate Change and European Union Directives on appliances and gas boilers created new landscape pressures resulting in the beginning of take-off in the low-energy homes niche. While the government continued its market-led approach, building regulations were tightened further. The government also introduced requirements for local authorities to draft a strategy for improving residential energy efficiency and report on measures regarding new and existing buildings through the Home Energy Conservation Act [40,36].

On the ground, concrete developments were not yet visible beyond individual pilots, and fell under predevelopment. Yet, local experimentation resulted in two separate home energy labelling schemes: the National Home Energy Rating (NHER) based on the Milton Keynes experiments [41] and Starpoint, which was a much simpler calculation ([42]; I25). Committed individuals continued pioneering projects.

4.1.2. 1999–2008: take-off

Take-off contains two policy sub-phases:

6 1999-2005: International climate commitments and active vision building for low-energy homes (nurturing)

7 2006-2008: A zero-carbon commitment and time of action (shielding), shadowed by the global financial crash

Early take-off (1999–2005), pertaining to a vision of zero-carbon homes, begun through vision building influenced by international and national commitments to reduce emissions. Internationally, the 2002 EU Directive on the energy performance of buildings set minimum standards for new buildings and existing buildings subject to major renovation,[4] paving the way towards "nearly zero-energy" announced much later, in 2010, by the European Commission.

New networks and high-profile projects generated practical and policy learning [43], many state and non-state intermediaries being active. New policy measures included the Decent Homes Standard for energy performance in social housing, Warm Homes and Energy Conservation Act 2000 addressing fuel poverty, the Energy White Paper 2003 (a first energy policy statement in 20 years), integration of EU requirements concerning new build into building regulations, and subsequent Energy Efficiency Action Plans [36].

While new build received more attention, measures to install insulation and more efficient windows and boilers addressed existing buildings. The Utilities Act 2000 gave powers to the government, instead of the regulator Ofgem, to set energy saving targets for supplier obligations ([44]; I26). Energy utilities implemented these through subsidising insulation, low-energy lighting and more efficient appliances [44]. Some regard this to date as "*the biggest energy efficiency policy in terms of carbon and energy savings with the possible exception of the condensing boiler regulation in 2005*", leading to a significant volume of supplier obligations carried out during 2002–2008 (I26). Demonstration programmes for small-scale renewables at the household and neighbourhood level were introduced in 2002 [45].

Active shielding followed during late take-off (2006–2008), including substantial policy commitments: the 2006 announcement towards zero-carbon new homes and the 2008 Climate Change Act. The zero carbon homes announcement was "*very ground breaking…back then the atmosphere was very different, everyone was really excited*" (I7). "*With zero carbon, it was an understanding from the [previous] government [Labour] that something significant needed to change*" (I2). Concerning new build, the Labour government implemented a voluntary Code for Sustainable Homes, tightened building regulations and set-up an industry-government body to address the delivery of new zero-carbon homes. While the house-building industry preferred voluntary policy approaches, it could not prevent the change of building regulations in accordance with the zero-carbon target [45].

Energy efficiency policy was placed in a new Department of Energy and Climate Change (DECC) in 2008. The zero-carbon homes announcement spurred action on the ground and new intermediary organisations and networks formed.

4.1.3. 2009–2016: backtracking phase

The backtracking phase comprises two policy sub-phases:

8 2009-2014: Gradual dismantling of government zero-carbon aspiration, while piloting continues; government austerity measures

9 2015-2016: U-turn in government low-energy homes policy and decreasing on-the-ground activity

During 2009–2014, take-off continued in many respects. Gradually diluting policies, however, weakened the protective space. The 2008 global financial crash led to a recession in the UK, resulting in government induced austerity measures and de-prioritisation of climate change [5]. The recession slowed down house building and influenced the availability of mortgages [46], resulting in debates on housing affordability [47].

[3] Milton Keynes was one of UK 28 towns set-up in the 1960s, inspired by Sir Ebenezer Howard's garden cities movement [78] to create places combining town and country living, green space, community landownership and job opportunities [78]. These new cities provided opportunities to develop new large scale housing concepts [39].

[4] In the UK, the minimum standards for existing buildings were not implemented [79].

A Conservative-Liberal Democrat coalition government elected in 2010 diluted the zero-carbon definition (I8) and changed the landscape for energy efficiency significantly (I28). Only a limited number of trials met the zero-carbon homes standards (I2). Many policies constituting protective space for new and existing low-energy homes were removed in 2015, before acceleration was reached. In 2016, the UK voted to leave the EU, adding further uncertainty. Many non-state intermediaries actively lobbied to reintroduce the low-energy homes policy.

4.1.4. 2017: uncertain future ahead

During the last 45 years, multiple policies and actors (e.g. academics, businesses, government departments, local authority organisations, NGOs and trade bodies) have been a part of the low-energy homes niche. Over time, new networks have emerged and intermediary actors have brought different organisations together and facilitated the delivery of low-energy homes.

In 2017, the number of new low-energy homes remained low. The Low Energy Buildings Database[5] listed 212 projects that had achieved at least a 70% reduction in primary energy and CO_2 emissions. New momentum may, however, be created by the ambitions in the new Industrial Strategy launched at the end of 2017 [48]. The Strategy aims to build a market for energy efficiency among homeowners and transform construction with better integration of energy efficiency and digital technologies [49].

4.2. Dynamics of transition intermediaries and policy development

Based on our analysis of the dynamics between intermediation and policy development, we make the following observations: (1) non-state transition intermediaries formed especially when government policy was weak or market-based; (2) state-affiliated intermediaries were set up during active low-energy homes policy; (3) existing organisations adopted intermediary-functions to advance low-energy homes in response to policy; and (4) intermediaries ceased to exist or change roles. In the following, we illustrate each of these findings empirically. Fig. 2 gives an overview of the phases vis-à-vis the establishment of new intermediary organisations or roles, addressed in more detail below.

4.2.1. Emergence of non-state transition intermediaries

Non-state 'voluntary' intermediaries specifically emerged at times of weak or market-based policy in the 1970s and 1980s, during *predevelopment*, to lobby in direct response to a lack of strong policy, or to initiate local action that went beyond existing policy requirements. While the intermediaries engaged more in either new or existing buildings, *late predevelopment* in particular saw the emergence of actors driving changes in the existing building stock.

Centre for Alternative Technology (CAT) and the Centre for Sustainable Energy (CSE) were established to initiate local action. CAT started in 1973 in Wales as a self-sufficient community aiming to provide autonomous eco-housing concepts [91] and resource efficient living [43] contributing in the new build sector. Its pilots and experiments are widely known, influencing today's low-energy housing community (I27, I28; [50]).

CAT's sister organisation CSE was created in 1979 in Bristol, to undertake retrofit demonstration projects locally. Its work has involved "*energy advice to the public and trying to take advantage of the policy programmes that are out there to develop local insulation schemes*" (I15). Over time, CSE's role expanded to a wide range of activities (I27) and national-level reach in education, advice, campaigns and policy analysis ([51]; I15). CSE's particular interest has been in "*trying things out and feeding learning into policymaking or practice by others*" (I15).

The Association for the Conservation of Energy (ACE) and National Energy Action (NEA) emerged in 1981, during *predevelopment*. ACE was established as an energy efficiency campaigning, research and lobbying organisation (I8) by 20 insulation companies (I15) active in the energy conservation industry [52]. It aimed to influence government policy to ensure continued regulation for residential energy efficiency in existing buildings, transmitting the views of its members (I8, I27). While ACE has worked in the interests of its members, it has also tried to advance energy conservation more broadly (I25, I28).

NEA was set up as 'Neighbourhood Energy Action' (later titled National Energy Action), an initiative by a group of university students who installed loft insulation for elderly people ([53]; I24). Initially, it was an incremental rather than a transitions actor and had no institutional backing (I24). However, NEA became a national charity campaigning to increase domestic energy efficiency [53] and one of the most influential organisations addressing fuel poverty (I27).

Later in *predevelopment*, when a market-approach being the best in delivering energy efficiency returned to dominate political beliefs (cf. [54]), new non-state intermediary organisations were established to promote low-energy new build (while also carrying activities supporting retrofit). These included the Association for Environment Conscious Building (AECB) in 1989 and the National Energy Foundation (NEF) in 1990. AECB is a network of builders, architects and engineers. It has had close involvement in policy processes, advocating for higher energy efficiency standards and an absolute approach for measuring building energy performance [55]. ACEB has been influential as pioneers (I27).

NEF was established as an independent charity to take forward some initiatives initially undertaken by the Milton Keynes Development Corporation (MKDC) [56], a government agency set up to develop a new city area. NEF's key activities were to deliver practical projects, inspire new low-energy building, advance knowledge and address market failures [41]. It has also recommended installers for low-energy and zero-carbon solutions [57] and lobbied the government to adopt a home energy rating system (I25, I29).

During late *take-off*, new intermediaries were again set-up. In 2006, the Good Homes Alliance (GHA) was established as a member organisation comprising housing developers, building industry and sustainability professionals promoting new sustainable homes [58]. It describes itself as a pressure and industry representative group, while being implicitly critical about current industrial systems in place as these are not delivering good quality homes (I22).

The UK Green Building Council (UKGBC) was established in 2007 to "*offer clarity, cohesion and leadership to a disparate sector, and to campaign for a sustainable built environment*" [59]. Its initiator and then Chief Executive had previously led a WWF sustainable homes campaign (I7). UKGBC also had the backing of mainstream Home Builders Federation [45]. Its aims included promoting sustainable building, influencing government policy, creating standards for new products, developing technical knowledge, and training [45]. It became one of key actors for the sustainable housing sector (I28), engaging with ministers and policy makers at the highest level (I5).

The new intermediaries emerging after significant policy announcements can be seen as a response to policy increasingly creating 'protective space'. This, in turn, allowed the intermediaries themselves to retain and recreate that space and provide nurturing for the niche. The new network-type intermediaries also represented a way to organise the disparate efforts to form a more coherent niche to respond to the changing policy environment, well evident in, for example, the aims of UKGBC.

4.2.2. State-affiliated transition intermediaries established in times of most active energy efficiency policy

Several state-initiated intermediaries have advanced the low-energy homes niche; the first established in *early predevelopment* in the 1970s. The Department of Energy created an Advisory Council on Energy Conservation (ACEC) in 1974 to fill a gap in energy demand expertise

[5] Low Energy Buildings Database: http://www.lowenergybuildings.org.uk (Accessed 14 May 2017).

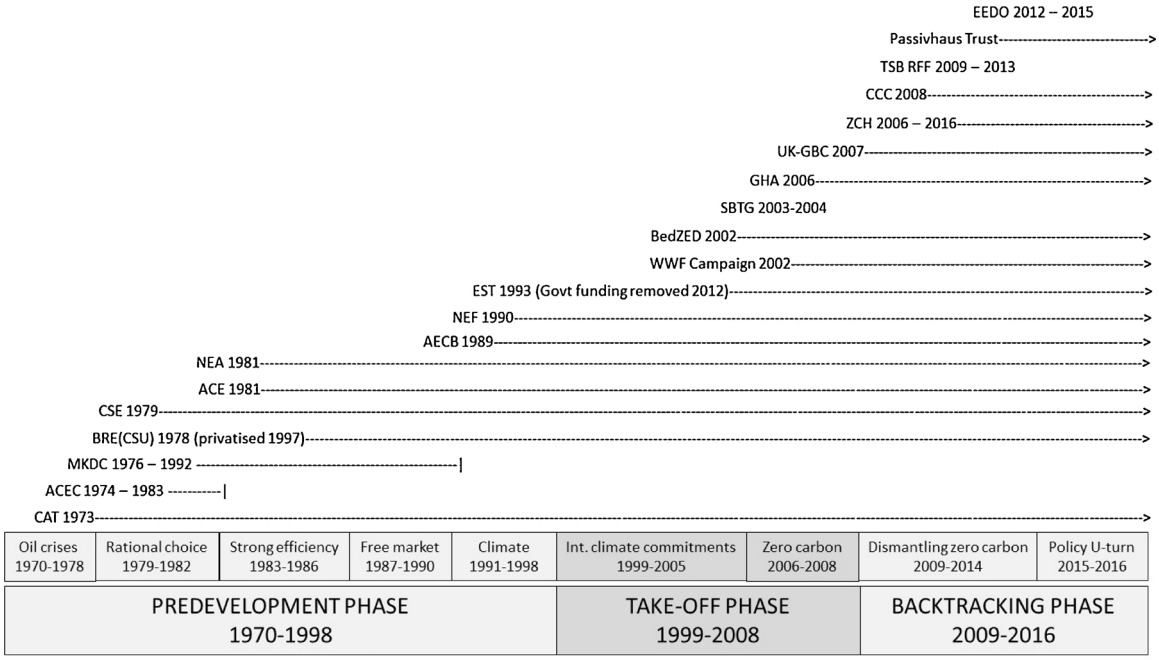

Fig. 2. Niche development and policy phases, with key intermediaries over time.

across sectors. ACEC was formed of engineers, energy supply industry representatives, energy consumers, a federation of trade unions, and academics, and it advised the Secretary of State for Energy [60].

The government did not establish new low-energy intermediaries until the 1990s, in *late predevelopment*, an era when climate change concerns became visible. Connected to the formalisation of UK climate policy [61], the government established the Energy Saving Trust (EST) in 1993 to focus particularly on household energy saving in the existing building stock. EST's roles were at the time to promote energy efficiency via advice and information campaigns and to manage grant schemes [45]. EST contracted NEF to manage a network of 30 Energy Advice Centres providing information on home energy efficiency [41]. In 2000, EST contributed to the establishment of a government-funded network intermediary Energy Efficiency Partnership for Homes, perceived as important for cooperation and dialogue (I27, I29). EST acted as an important intermediary for policy advice and implementation during *take-off*, particularly until it was detached from the government in England and Wales (but not in Scotland) in 2010 [36], at the start of the *backtracking* phase.

During *late take-off*, in 2008, and following the zero-carbon homes announcement of 2006, the government, together with industry, set up the Zero Carbon Hub (ZCH). ZCH, a not-for-profit organisation, brought together key stakeholders to develop a framework for the delivery of new zero-carbon homes [62]. ZCH, initially part-funded by government, convened industry experts and government partners to undertake research on the technical and economic feasibility of the zero-carbon homes target [62]. It established a specific Timeline Group in 2009 with the objective to "*carefully consider those factors which are enabling and assisting the journey to meet the 2016 Zero Carbon trajectory and also to consider the road blocks and concerns that are affecting this objective*" [63]. Members of the group included industry, trade associations and NGOs (e.g. intermediary organisations EST, UKGBC and WWF) [64] and the group reported directly to the '2016 Task Force' set up by Yvette Cooper, the Minister of Housing and Planning [64].

During *backtracking*, in 2012, the government still set-up a new Energy Efficiency Deployment Office (EEDO) within DECC to deliver a new energy efficiency strategy that year [36].

Beyond the low-energy homes focused intermediaries, during *take-off*, Friends of the Earth lobbied for a Climate Change Act (I26), which became law in 2008. The Act established an independent Committee on Climate Change (CCC) that continues to monitor and advise on the delivery of carbon budgets [36].

4.2.3. Existing organisations subsuming transition intermediary roles

Frequently, intermediation occurs by established organisations adopting intermediary roles in a new sector (e.g. [33]). This is evident for state-affiliated and non-state intermediaries advancing the UK low-energy homes niche.

In the 1970s, during *early predevelopment*, energy efficiency became a focus for existing government organisations. The Energy Technology Division in the Department of Energy was renamed the Energy Conservation Unit (ECU) in 1977 by Labour Energy Secretary Tony Benn, bringing energy demand on par with energy supply in policy-making [36]. In 1983, during *third sub-phase of predevelopment*, a new Energy Secretary, Peter Walker, renamed ECU as the Energy Efficiency Office (EEO) that produced a range of Best Practice guides on energy use in dwellings "*to persuade builders, householders and landlords to improve the energy efficiency of properties*" ([65]: 310). Also, MKDC established an Energy Consultative Unit in 1976 [66].

An Energy Conservation Unit (BRECSU) was set-up under Building Research Establishment (BRE) during *early predevelopment* in 1978, initiating a period of BRE becoming active in advancing energy efficiency. BRE was initially created in 1972 by merging three government-funded research laboratories [67]. It operated mainly as a technical organisation between the research community, practitioners and sector professionals (I13). However, BRE became "*less influenced by industrial requirements and progressively more aligned to the support of Government needs*" through a "*'customer-contractor' relationship in Departmental research funding*" ([67]: 287). *"Energy and environmental… work received new emphasis in the next decade, with a large programme promoting energy efficiency in the building sector that grew from small beginnings in the mid-1980s to employ around 70 staff by 1993"* ([67]: 287).

During *early backtracking*, to comprehensively address the energy performance of existing buildings, the government and the social

housing sector jointly set up Retrofit for the Future, a £17 million programme funded by the government's Technology Strategy Board (now InnovateUK) in 2009–2013 [68]. It took a whole house approach to retrofitting social housing, with an aim to reduce CO_2 emissions by 80% [68].

Environmental NGOs have sometimes acted as temporary transition intermediaries [69] to lobby advances in low-energy homes policy. In the late-1980s, Friends of the Earth ran a national campaign for the development of mandatory supplier obligations around domestic energy efficiency, supported by ACE; this drove the take-up of insulation measures across the country (I1, I14, I15, I26). In 2002, during *early take-off*, WWF-UK's 'One Million Sustainable Homes' campaign called for the government to make a public commitment to develop a million 'sustainable homes' (including retrofitting the existing stock and building new homes) [37] and to enable the practice to become standard by 2012 [70]. Its role was unique from other environmental groups in the UK, because WWF had an insider role with the government and industry [71,45]. WWF effectively acted as an intermediary taking on extensive networking, learning and visioning activities. It was the only NGO in the Sustainable Buildings Task Force, and carried out audits on the sustainability progress of twelve large building firms ([45]: 340). Importantly, its One Million Sustainable Homes campaign created a vision towards forthcoming policy design.

Other types of actors, also, became intermediaries for low-energy homes during *late predevelopment*. Bioregional, established in 1994 as a social enterprise for environmental sustainability, became interested in sustainable buildings in 1997. Initially considering building a new office space, Bioregional completed a multi-purpose BedZED development in 2002 (I19). BedZED became one of the most famous sustainable housing developments in the UK, receiving media attention and public interest [7]. Bioregional completed a more commercial sustainable building project, One Brighton, in 2010 [50].

Some social housing associations have also intermediated for low-energy homes. They were particularly active in the 1980s and 1990s, perceiving that accommodation should be as energy efficient as possible for people on low incomes (I25). Housing associations have tended to "*be much more forward-looking on behalf of their residents, than speculative house builders*" (I3). Thus, certain housing associations, such as Peabody Trust, have acted as niche intermediaries for low-energy building. Peabody contributed to visioning and learning in the BedZed development, being in charge of post-occupancy monitoring [72].

4.2.4. Intermediaries ceasing to exist and changing roles

While new intermediary organisations have been set-up, they have also been abolished. Intermediaries have also altered their roles depending on (a) changes in their funding or mandate, or (b) the development of niches, changing problem definitions within the regime or new landscape pressures. During *predevelopment* and *take-off*, a larger number of intermediary organisations emerged and took active roles to advance the niche than ceased to exist, but many now exist at reduced capacity.

State-affiliated intermediaries in particular have been abolished. A decline in oil prices in the early-1980s coupled with rational choice thinking in the government influenced the removal of ACEC in 1983, during *third predevelopment phase*, despite evidence that government programmes on energy demand reduction had worked. Over thirty years later, in 2015, during *backtracking phase*, state intermediaries EEDO and ZCH were abolished in connection to the removal of almost all policies addressing low-energy homes.

Changing roles were evident in two ways. First, many locally established non-state intermediaries gradually began to have national influence. Examples include CSE expanding from Bristol-based pilots to national policy analysis and evaluation, NEA starting out as voluntary action by a group of students and later becoming an influential national campaigning charity, and NEF being established as an independent charity by MKDC and becoming a national intermediary.

Second, initially state-affiliated intermediaries have become more akin to independent charities or consultancies over time. BRE was privatised in 1997, during *late predevelopment*, and has since been owned by a charitable foundation [67]. It had a significant role in aggregating and sharing knowledge, e.g. through the Energy Efficiency Best Practice Programme, which diminished through privatisation (I25, I27, I28, I29). In England, EST was initially funded through a levy on energy bills and Energy Efficiency Standards of Performance [36]. The government removed core funding from EST in 2012, during *gradual dismantling*, in a bid to save money and remove quasi-autonomous non-governmental organisations [36]. Subsequently, EST has had to apply and compete for funding alongside other non-state intermediaries and changed towards being a lobbyist (I26–28).

While the upsurge of policies created much space for new intermediaries during *late take-off,* from 2006 onwards, the policy cuts combined with landscape developments led to a curtailed operational space for many intermediaries since 2015. Social housing funds' resources to pilot low-energy solutions have diminished, following reduced subsidies and new legislation pertaining to social housing (I14), though they are still important (I28). The reduction in government subsidies has also led to intensifying competition over funding and mandate for some existing intermediary organisations. For those intermediaries dependent on membership funding, "*competing for members… has become much more acute in the last two or three years, because until then, the big companies would actually pay for membership of lots of organisations*" (I23).

4.2.5. Evolving ecology of intermediaries

Tables 2 and 3 summarise how transition intermediaries for low-energy homes have emerged, changed roles and abolished over time. While some intermediaries have focused mostly on either new or existing buildings, many of them have addressed both sectors to a degree and differently in successive phases. Many also interlink with each other, for example, through connections via their founding bodies, participation in network-based intermediary organisations, or contribution to the same policy processes. Interviewees described both

Table 2
Summary of non-state transition intermediaries: emergence and existing organisations taking up intermediary roles.

Phase	Policy	Intermediation
Predevelopment (1973–1998)	Sub-phases of weak or market-based policy	• Emergence of new non-state intermediaries (CAT for new build, CSE for retrofit) independently of policy but with later policy influence • Emergence of new non-state intermediaries (AECB and NEF for new build, ACE and NEA for retrofit) responding to weak policy • Some social housing funds taking on intermediary roles to pilot low-energy concepts
Take-off/nurturing (1999–2005)	Initiation of climate policy and vision building for zero-carbon homes	• NGO (WWF-UK) taking on an intermediary role to lobby for new sustainable homes policy
Take-off/shielding (2006–2008)	Strong policies driving zero-carbon homes	• Emergence of new non-state intermediaries (GHA, UKGBC, mainly for new build) to bring coherence to the niche following zero-carbon homes commitment and being critical about current practices

Table 3
Summary of state-affiliated transition intermediaries: emergence and existing organisations taking up intermediary roles.

Phase	Policy	Intermediation
Predevelopment (1973–1998)	Sub-phases of strong regulation-oriented policy	• Establishment of new state-affiliated intermediaries (ACEC, BRECSU, EST) to increase and transfer energy efficiency knowledge • Changing roles of government units (EEO) to take on intermediary roles to implement energy efficiency policy • Some new intermediaries (EST) initiated to formalise policy
Take-off/shielding (2006–2008)	Strong policies driving zero-carbon homes	• Establishment of new state-affiliated intermediaries (ZCH for new building, CCC cross-sectoral) to design, implement and monitor policy
Backtracking (2009–2016)	Dilution and removal of policies	• Removing government funding from previously state set-up intermediaries (EST) • Abolishment of low-energy intermediaries (ZCH, EEDO) • Technology Strategy board carrying out a programme on retrofit

collaboration and competition to exist simultaneously (I27, I28).

Fig. 3 illustrates the ecology of intermediary organisations in four different phases: mid-predevelopment (1988), end of predevelopment (1998), end of take-off (2008) and backtracking (2016). It shows how the intermediaries position, in terms of new build and/or retrofit, and connect with each other (these links are tentative and others may also exist). Between 1988 and 2008, there was a significant expansion of the ecology of intermediaries. Government-initiated network organisations, the Zero Carbon Hub in particular, coordinated stakeholder involvement in policy development in 2008. Such network intermediaries, besides their core staff, have comprised other intermediary organisations and actors as members. In 2016, many of the same organisations still existed but in reduced capacity and without the support of network intermediaries.

As a novel contribution to research, our study shows the accumulation of an increasing number of intermediaries, although some have stopped operating over time, while others reduced their influence. It shows in particular how state-affiliated intermediaries are more susceptible to abolishment or to have their support withdrawn, particularly influenced by the prevailing policy paradigm. This indicates the importance of a broader ecology of intermediaries that also includes non-state intermediary organisations to keep sufficient momentum alive, even when individual intermediary organisations cease to exist. It is also clear that intermediaries are only a part of a broad range of actors needed for a transition (e.g. [73]).

4.3. Influence of intermediaries on low-energy homes policy

The intermediary organisations mentioned above have shaped policy development in various ways, explicitly and implicitly. The different types of influence include:

1 Piloting and experimenting that demonstrate what is possible, influencing political vision building and gradual tightening of policy demands: usually carried out by non-state intermediaries (CAT, CSE, Bioregional, AECB) but also by some state-affiliated intermediaries (Innovate UK)
2 Influencing the development of standard setting and new legislation:

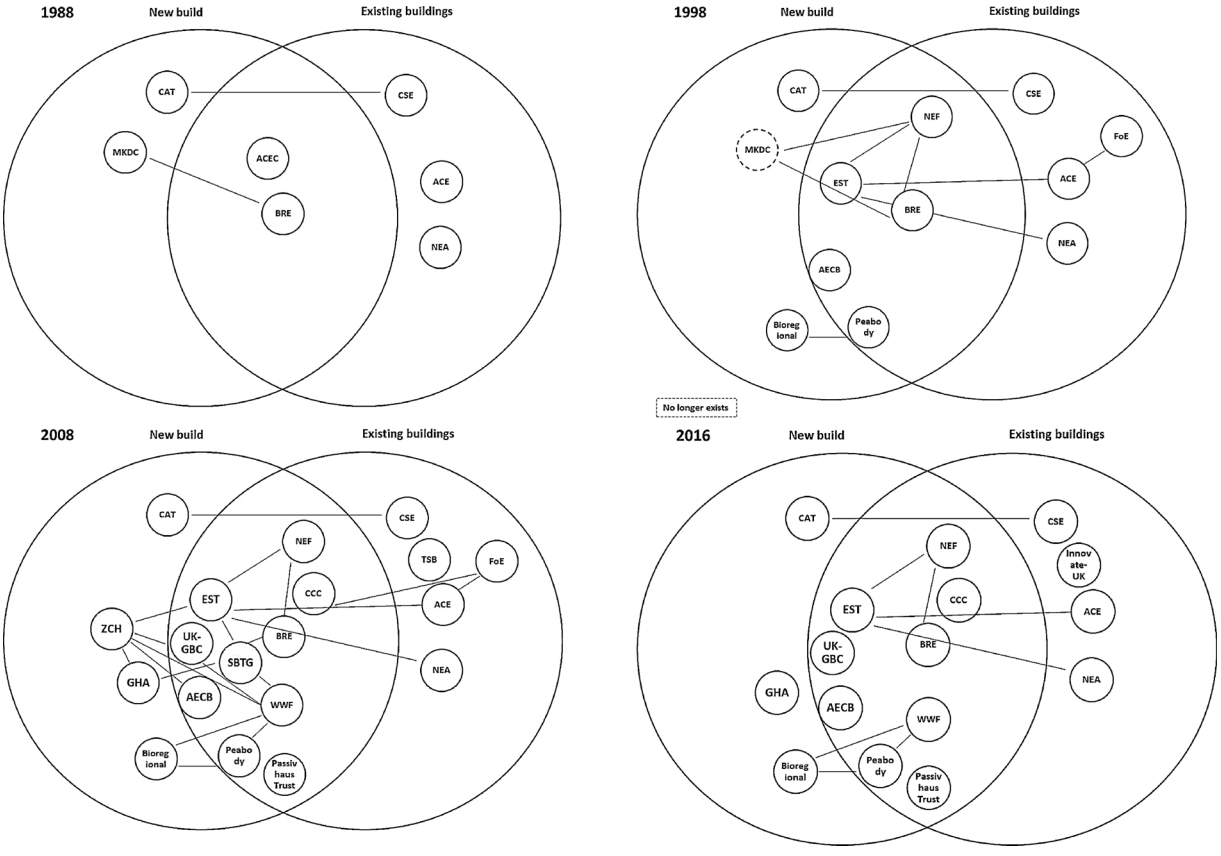

Fig. 3. Ecology of transition intermediaries driving energy improvements in new and existing buildings, and illustrative connections in four different times.

Table 4
Examples of intermediary influence on policy.
Sources: [74,39,42,75,40,45,76,56,68,77]; I5, I11, I16, I24, I25, I26, I27, I28.

Phase	New buildings	Existing buildings
Predevelopment (1973–1998)	• Pilot projects set up by non-state intermediaries, including CAT, created expectations of what was possible • Energy Park by state-affiliated intermediary, MKDC, showcased houses going beyond building regulations, creating further expectations • Voluntary National Home Energy Rating (NHER) scheme by NEF pushed government to adopt Standard Assessment Procedure developed by BRE	• Pilot projects set up by non-state intermediaries, including CSE and NEA, created expectations of what was possible • NHER by NEF addressed also existing buildings • ACE conducted a two-year campaign leading to the Home Energy Conservation Act; NEA was important in implementing the ideas • ACE produced reports to government on energy efficiency supplier obligations • EST involved in drafting the details of supplier obligations
Take-off (1999–2008)	• Pilot projects set up by non-state intermediaries, including CAT and Bioregional created expectations of what was possible • BedZED (with Bioregional contribution) influenced local planning authorities, e.g., the 'Merton rule' set 10% renewable energy requirement for new developments, and was visibly referred to in government policy documents • WWF million sustainable homes campaign led to the set-up of Sustainable Buildings Task Force, followed by improvement of energy efficiency requirements in building regulations, a voluntary Code for Sustainable Homes standard (influenced by BRE) and 2016 Zero-Carbon Homes target • Intermediaries (e.g. BRE) aggregated pilot experiences to advocate best practice	• Pilot projects set up by non-state intermediaries, including CSE, created expectations of what was possible • EST and ACE came together with the Combined Heat and Power Association to discuss the approach to supplier obligations, jointly influencing the Utilities Act
Back-tracking (2009–2016)	• ZCH supported by GHA and AECD influenced how fabric energy efficiency standard was added to building regulations	• EST set up retrofit pilots in social housing • Retrofit for the Future Programme coordinated by a state intermediary TSB created expectations and demonstrated how whole house retrofits can be carried out in practice (and its challenges)

by a mix of state (BRE, EST, ZCH) and non-state intermediaries (NEF, ACE; EST after privatisation)
3 Carrying out and coordinating assessments aggregating latest knowledge, in support of policy development: by a mix of state-affiliated (BRE, EST) and non-state intermediaries (CSE, UKGBC; EST after privatisation)
4 Implementing and translating policy to practice: usually carried out by state-affiliated intermediaries but sometimes sub-contracted to non-state intermediaries (EST, NEA)
5 Creating and managing networks to lobby for new more transition-oriented policies: by non-state intermediaries (ACE, GBC, GHA, AECB, WWF, FoE)
6 Creating and managing public-private networks informing the government: state established but with public-private composition (ACEC, ZCH, SBTG)

Table 4 shows examples of intermediary influence on national government policy. The intermediary organisations have also influenced policy regionally (I27, I28). The following sub-sections illustrate intermediary influence on policy development regarding the first and second types.

4.3.1. Intermediary influence through pilot projects

Pilot projects set up by non-state intermediaries, including CAT, CSE and Bioregional, have created expectations of what is possible in new build and retrofit. CAT has since the 1970s carried out pioneering projects with long-term influence through an extensive network (I27, I28; [50]).

The BedZED development, steered and disseminated by Bioregional (I26, I28) inspired national government to display it as an example of sustainable housing [43]. The project was a "*focal point for policy makers, uniting otherwise disparate actors, and thereby creating further opportunities for innovation*" ([75]: 2511). Multiple policy documents referred to it during *early take-off* and it informed discussions on changes in building regulations pertaining to energy efficiency [75]. It also influenced the planning policies of local councils [75].

Other intermediaries, such as local planning authorities and BRE (pre-privatisation), have aggregated learning from these and other pilot experiences, advocating best practice ([7]; I25, I27, I28, I29).

State-affiliated intermediaries have also had an occasional role in piloting. MKDC's low-energy pilots trace back to 1973. It was especially active in 1986, during *pre-development*, setting up an energy park and an energy standard that went 30% beyond building regulations, drawing on work by BRE (I25; [39]).

In whole house retrofit, piloting was supported by the Technology Strategy Board (now Innovate UK) programmes, most importantly the Retrofit for the Future during 2009–2013. Only three of 45 projects funded under the programme met the initial 80% CO_2 emission reduction objective [68]. The programme resulted in learning that illustrated the challenges of whole house retrofit: who is coordinating projects, how residents deal with the disruptive nature of retrofit works, and whether designed energy savings materialise post-retrofit [68]. It influenced the initiation of some new retrofit projects, and even the formation of SME cooperatives to take on projects funded by the programme (I11). Some projects achieved architectural awards and attracted media attention [77]. However, many interviewees could not detect longer-term impacts in terms of scaling up (I25–27).

4.3.2. Intermediary influence on standard setting and new legislation

Both state-affiliated and non-state intermediaries have influenced standard setting and legislation for low-energy homes, while this is ultimately a government activity. Of non-state intermediaries, some organisations seem more visible and influential in policymaking than others, ACE being one such example (I24-27). In addition, EST has had an important role, first as a state-affiliated intermediary, and then as non-state intermediary (I26, I29), in the latter capacity being less influential than before (I27, I28).

The independent charity NEF was active in pushing for an energy-rating scheme during *pre-development*. Its National Home Energy Rating (NHER) scheme for new and existing buildings was influenced by state-affiliated BRE's BREAAM standard (I25), and developed based on R&D undertaken by state-affiliated MKDC [56]. NHER was one of two independent labelling schemes developed at the time, NEF pushing the need to have a national energy rating

(I29). Initially the government encouraged both schemes [42] and urged building societies to contemplate NHER ratings when considering mortgages [74]. However, influenced by the increasing push to adopt an energy-rating scheme and to bring consistency to measuring building energy consumption, the government launched a Standard Assessment Procedure (SAP) in 1992; this followed advice from civil servants that an independent scheme like SAP is better than the proposed alternatives ([56,42,41]; I25). Yet, some see SAP as a stripped down version of NHER, with the same people involved in developing NHER and SAP (I29). State-affiliated BRE formulated SAP, which was updated several times and included in building regulations in 2005 [80,55].

ACE has been very active in lobbying for new legislation (I25–27). For example, it played an important role in the formation of the Home Energy Conservation Act in 1995 (I26), during a two-year campaign [40]. Later, together with EST and Combined Heat and Power Association, ACE influenced the process resulting in the Utilities Act, the organisations jointly having good political influence, knowledge of policy details and support from industry (I24, I26).

Following the WWF-UK's 'One Million Sustainable Homes' campaign, during *early take-off*, the government established a Sustainable Buildings Task Group (SBTG) in 2003, with a remit to "*advise the Government on practical and cost effective measures to improve the sustainability of buildings*" ([81]: 6). SBTG's members included WWF-UK, building and construction companies, architects, social housing providers, EST, waste companies and local authorities [81]. It produced a 'Better buildings – better lives' report in 2004, which included recommendations to government and industry, such as a 25% energy efficiency improvement in Part L of building regulations and a national Code for Sustainable Building (CSB) [81].

The Code was recommended to be based on BRE's BREEAM standard, introduced already in 1990 for the non-domestic sector and extended as the Ecohomes standard for the domestic sector in 2000 [45,82,76]. SBTG recommended also a joint industry-government venture that would develop, establish and manage the Code, helping give a clear direction to industry [81]. A number of actors, including UKGBC, lobbied for The Code (I28). These developments lead to the launch of the Code for Sustainable Homes in December 2006 as a voluntary standard, aiming to encourage industry to go beyond the minimum standards of building regulations [45]. It acted as a benchmark for the 2016 zero carbon homes announcement and many local authorities across the UK applied the Code in their planning requirements.

The Zero Carbon Hub (ZCH) had working groups aiming to develop a zero-carbon definition and policy for fabric energy efficiency, carbon compliance (e.g. on-site low-carbon and renewable energy) and allowable solutions (e.g. offsite measures for reducing carbon). On fabric energy efficiency, these aimed to encourage innovation in building fabric products by seeking "*to set the standard at a challenging level, yet in a way that could be achieved by a variety of different technical solutions*" ([55]: 171). For example, AECB, drawing on their Passivhaus approach, called for stricter fabric energy efficiency standards and, with GHA, for a move to measuring absolute energy use [55]. Another issue of debate was whether fabric energy efficiency standards would require also mechanical ventilation and heat recovery, supported by AECB but opposed by house builders [55].

Already preceding ZCH, there was significant debate and disagreement regarding the level of on-site renewable energy and other allowable solutions (e.g. carbon compliance) versus fabric energy efficiency [55]. Organisations, including UKGBC and WWF, supported a strict regulatory standard for 100% on-site renewables "*to encourage innovation in on-site technologies*", UKGBC later changing its position ([55]: 170). However, a national housebuilding crisis gave house builders an excuse to question already agreed fabric energy efficiency standards and levels of carbon compliance on cost-basis (I7).

Eventually, the 2014 update of building regulations included a fabric energy efficiency standard for the first time. ZCH came up with actual numbers and were influential in policy development (I16), while EST helped particularly in ZCH work on marketing and demand stimulation for zero-carbon homes (I5). However, ZCH failed to deliver an influential standard because of house builders' strong influence, involving people with insufficient technical expertise, and leaving several issues unresolved (I29).

The situation in 2017 was rather modest regarding intermediaries' policy influence. A representative of an intermediary stated that: "*an awful lot of us are less effective than we used to be, because membership has dropped off in most organisations, because of funding constraints. I think everybody's ability to influence has been reduced, in the vast majority of cases. It is not that particular organisations have gone. It is just that all of us struggle more than we used to, to be a voice*" (I23). Many intermediary organisations are undergoing restructuring to survive.

5. Discussion and conclusions

We examined the long-term trajectory of the UK low-energy homes niche, developing in the context of energy efficiency and climate policy. We paid specific attention to the interplay between policy development and the emergence and influence of transition intermediaries. We were interested in when and why new intermediary organisations had emerged or existing organisations subsumed intermediary roles for low-energy homes, and what influence these intermediary organisations have had on policy development. Furthermore, we extended existing literature on intermediation by illustrating empirically how the dynamic 'ecology of intermediaries' (cf. [11]) has changed over time with respect to policy formation, generating novel insights to literature.

5.1. Emergence of intermediary organisations and roles

First, we found that in the *predevelopment* phase, new non-state transition intermediaries specifically emerged at times of weak or market-based policy as a counter action to a lack of protective space provided by policies. These actors initiated local action and lobbied for policy change. This is an interesting finding partly contradicting previous research, which has found that a stable, long-term policy and financial context creates a fruitful environment for intermediary activities (Backhous, 2010). Our novel finding may be explained by the lack of attention in previous research on intermediaries addressing different phases of transition.

However, we also found that, in the *late take-off phase*, policy developments pertaining to zero-carbon homes (with potentially destabilising influence for new build) improved the operational space for non-state transition intermediaries through increasing needs and resources to pilot, scale-up and implement policy. In this phase, new network-type intermediaries, such as the UK Green Building Council (UKGBC), coordinated activities to form a more coherent niche to respond to the changing policy environment and to further influence the formation of protective spaces and facilitate niche acceleration. This finding supports Smith et al. [83] who in the context of community energy observed how intermediaries try to create a coherent voice for the niche towards policymaking.

Second, state-affiliated intermediaries formed – as either new

organisations or existing organisations subsuming intermediary functions to advance low-energy homes – when policy for building energy efficiency was strong in the *predevelopment* and *take-off* phases. Interestingly, by 2016, many such intermediaries had ceased to exist or had transformed their role to non-state intermediaries, creating a gap in the ecology of intermediaries. Instead of what might be theoretically expected [29], many state-affiliated intermediaries, such as the Energy Efficiency Deployment Office (EEDO) and the Zero Carbon Hub (ZHB), disappeared before, rather than after, niche development accelerated.

Third, non-state and state-affiliated intermediaries often jointly influenced further policy development; interestingly even taking similar roles in niche nurturing processes (cf. [20]). Both groups of intermediaries engaged in the articulation of expectations and visions, learning, and connecting actors, identified previously as core functions of state-affiliated intermediaries by Kivimaa [10].

In terms of influence, we identified six types with illustrating examples. For example, some intermediaries piloted new projects that were aggregated by other intermediaries, and were acknowledged in local and national policy. Specific lobby actions by non-state intermediaries informed the development of new policies, such as the Standard Assessment Procedure (SAP) for buildings, the Utilities Act and the Code for Sustainable Homes. Subsequently, state-affiliated intermediaries refined the initial ideas for concrete policy recommendations to be adopted by the government. Yet, simultaneously much intermediary action existed that did not result in concrete policy changes, linking to the complexity of intermediary action and policy change identified also by Smith et al. [83].

5.2. Insights on the ecology of intermediaries

We showed how an extensive ecology of intermediaries has formed supporting low-energy homes niche development, and how this ecology has changed over time with new organisations being established and others ceasing to exist or changing roles. While this ecology is connected through mutual aims to support the broader low-energy goals and to destabilise the incumbent practices and institutions maintaining the high-energy building stock, it is not a seamlessly functioning network. Each intermediary organisation has its own specific goals deriving from a specific ideology and mandate, and the people and interests involved (whether public, commercial or civil society). Intermediaries are, thus, strategic actors [88], which leads to the ecology being divided by the specific goals and action proposals of the different intermediaries. Furthermore, similarities may also create a need to separate rather than unite actions, when funding is limited and the survival of the organisation is threatened – creating a need for a differentiated, rather than a common voice pertaining to low-energy homes.

The interconnections between the intermediaries can be long-term, e.g. tied to their official connections (such as between the Centre of Alternative Technology and Centre for Sustainable Energy as sister-organisations) or temporary, linking to ongoing policy processes or projects. Links also form through people that move from one organisation to another. The analysis here indicates sub-networks forming around retrofit and/or new build, and around practice-oriented or policy-oriented action. A further dimension is national versus regional action, which is beyond the scope of this study.

Interestingly, while *take-off* seemed to have halted in 2015, several intermediaries, e.g. the Association for the Conservation of Energy (ACE), Energy Saving Trust (EST), and the UK Green Building Council (UKGBC), still exist and actively promote low-energy homes. Their resources, however, have reduced, leading to more competition over funding. The low-energy homes niche has backtracked to a phase, where government policy does not explicitly support intermediation or further development of whole house retrofits or zero-carbon new homes (while consultation is ongoing for the former). Despite this backtracking, the ecology of intermediaries continues to self-organise and remains committed to accelerating the niche, but is less effective than before – facing an increasing battle for survival and creating cracks within the ecology of intermediaries.

5.3. Prospects and needs for further research

For environmental governance more generally, our research raises interesting questions. For example, with increasing attention given to polycentric governance (cf. [5]), there is also a need for intermediaries to connect different spheres of governance. The same applies for accelerating momentum for experimentation in climate governance (cf. [84]), where intermediaries are needed to connect experiments and aggregate lessons. Yet, as our findings show, while changed policy can curtail intermediary opportunities (even at the absence of direct financial or political dependence on the government), it remains open who supports these intermediaries that are needed in fragmented governance settings, and how they obtain their resources to operate.

This work supports the existing literature [28,90] that has recognised intermediaries as a policy tool in relation to Strategic Niche Management. This means that governments can support the future progression of niches into more sustainable directions by allowing such intermediary actors to exist and thrive. Yet, intermediaries are struggling due to limited resources and a rapidly changing policy context, the latter requiring repacking "*their activities for each new policy change and funding opportunity*" ([85]: 40). The changing environmental governance landscape and the questions posed above show a need for further research on the roles that intermediary actors can play in governance for sustainability transitions. In addition, further research is needed on the dynamics of policy and transition intermediaries, in particular how intermediaries for the existing regime work to counter the actions of transition intermediaries.

Data statement

The work used interviews and secondary literature as data. Due to ethical reasons, interview data cannot be made available.

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Appendix A. Phases of development in the UK low-energy building niche

Sources: [38,39,63,7,61,45,55,37,41,36,89,50,35]; interviews 1–29.

Phase	Landscape pressures & international developments	Energy efficiency politics and policy (regime)	Local experimentation (niche)	Intermediaries and year established
Pre-development				
1970–1979 Oil crises, initiation of active energy efficiency policy and pioneers of alternative, sustainable housing emerge	Two oil crises (1973 and 1979) followed by significant increases in oil prices, UK becomes member of EU (1973)	First Department of Energy (1973), switch from Conservative to Labour government (1974). Introduction of energy saving campaign (1975), of Part L 'Conservation of Fuel and Power in New Dwellings', to building regulations (1976), and energy efficiency programme (1977). Energy demand issues gained attention alongside supply.	Emergence of environmentally motivated individuals and groups developing eco-homes, solar homes and autonomous homes.	- Centre on Alternative Technology (CAT) (1973) - Advisory Council on Energy Conservation (ACEC) (1974) - Energy Consultative Unit to Milton Keynes Development Corporation (MKDC) (1976) - Energy Conservation Unit to Building Research Establishment (BRE) (1978)
			Some government support to build a first experimental solar house in Milton Keynes and increased attention by Building Research Establishment on energy conservation.	
1979–1982 Economics of energy and rational choice dominate but influence the emergence of new intermediaries for low-energy housing	Decline in oil prices; influence of the discovery of North Sea oil and gas.	New Conservative government (1979), dominated by beliefs that energy prices will reduce demand.	Grassroots pilots continue, e.g. Centre for Sustainable Energy (CSE) 'Future City Home' and National Energy Action (NEA) initiative to set up loft-insulation.	- Centre for Sustainable Energy (1979) - Association for the Conservation of Energy (ACE) (1981) - National Energy Action (NEA) (1981)
			Formation of lobby groups to continue regulation on energy efficiency.	
1983–1986 Come back of strong energy efficiency agenda and large scale pilots in Milton Keynes	Developments in other countries (Japan, US) in energy efficiency.		Showcasing 53 innovative energy efficiency houses in Milton Keynes "garden city" that came a research hub for sustainable buildings concepts.	- ACEC removed (1983)

		Second conservative government (1983) with a new Energy Secretary championing energy efficiency. Set-up or regional energy efficiency offices; best practice guidelines; tightening Part L of the Building Code; "Energy Efficiency Year" (1986).		
1987–1990 Free market and information approach to energy efficiency, and non-state intermediaries lobbying for stronger policy	Bruntland report raising awareness of sustainable development (1987), privatisation of the UK electricity industry (1989);	Third conservative government (1987) with free-market focused Energy Secretary. Cuts to Energy Efficiency Office budgets, demonstration initiatives and subsidies with focus on information and advise	Emergence of new actors to promote environmentally sustainable construction, to deliver projects on low-energy buildings, and advocate higher energy efficiency standards.	- Association for Environmentally Conscious Building (AECB) (1989) - National Energy Foundation (NEF) (1990)
			Friends of the Earth campaign to introduce supplier obligations for energy efficiency.	
1991–1998 Climate change concerns, mainstreaming energy efficiency in building assessment, and first steps towards passive house and zero carbon designs	United Nations Framework Convention on Climate Change (1994); first European Union Directives addressing energy efficiency (1992)	Climate policy begins to influence energy policy but with little impact for radical domestic action following the Conservative government (1992) market-led approach. Yet some new policies, such as the Home Energy Efficiency Scheme, Standard Assessment Procedure for new buildings, 30 Energy Advice Centres, Home Energy Conservation Act setting requirements for local authorities to report on energy conservation measures and tightening of Part L of building regulations.	Continued focus on sustainable lifestyles, with novel pioneering projects but typically still driven by committed individuals	- Energy Saving Trust (EST) (1993)
			NEF active in proposing a new home energy rating scheme based on R&D by MKDC. Emergence of the Passivhaus concept in Germany and taken up by AECB to advocate stricter energy efficiency standards	
Take-off				
1999–2005 International climate commitments and active vision building for zero carbon homes	International and national commitments to reduce greenhouse gas emissions	Labour government 1997 and 2001), leading the energy efficiency policy moving under new Department of the Environment, Transport and the Regions. Decent Homes Standard setting objective for energy performance in social housing, Energy White Paper, integration of EU requirements into building regulations, Energy Efficiency Action Plan, and other new policy recommendations arriving from multi-stakeholder working group set up by the government	High profile projects demonstrating zero carbon building, including BedZED, with influence on local policy making.	- WWF-UK campaign (2002) - Bioregional & Peabody Trust complete BedZED (2002) - Sustainable Buildings Task Group (SBTF) (2003)
	New European Union Directives on the energy performance of buildings to "nearly zero energy" (2002)		WWF-UK campaign for a million sustainable homes	
			Research on the "40% house"	

2006–2008 A zero carbon commitment and time of action	Increasing attention to climate change, including the Stern Review published in the UK (2006) and the UK Climate Change Act (2008)	Labour government continues in power (2005). Implementing recommendations of SBTF, including voluntary Code for Sustainable Homes (applied by local authorities in their planning requirements), and an announcement that new homes should be zero carbon from 2016 onwards, the tightening of buildings regulations, and the industry-government network Zero Carbon Hub (ZCH). Energy efficiency policy moves under the new Department of Energy and Climate Change (in 2008).	Zero carbon homes announcements spurs a lot of action the ground, including Bioregional and incumbent construction company development in Brighton. New intermediaries are set up, e.g. UK Green Building Council (UKGBC) "to offer clarity, cohesion and leadership to a disparate sector" [59] and lobby for specific policy designs for energy efficiency.	- Good Homes Alliance (GHA) (2006) - UK Green Building Council (UKGBC) (2007) - Zero Carbon Hub (ZCH) (2008) - Climate Change Committee (CCC) (2008)
Backtracking				
2009–2014 Gradual dismantling of government zero carbon aspiration, while piloting continues	Global financial crash (2008)	Conservative-Liberal Democrat coalition government in power (2010). Removing 'regulated' energy from zero carbon definition and adding 'allowable solutions', i.e. emissions could be mitigated by onsite measures, following a too ambitious target and opposition from the building industry. Delay and reducing ambition of revised building regulations. These lead to 'strong and ambitious' zero carbon homes pathways becoming broken. Green Deal, deemed later a failure, replaced previous energy retrofit subsidy schemes.	Technology Strategy Board (TSB) funded research on whole house energy retrofits of existing buildings.	- Technology Strategy Board (TSB) Retrofit for the Future Programme (2009–2013) - Passivhaus Trust (2010) - Energy Efficiency Deployment Office (EEDO) (2012) - Government core funding removed from EST and Carbon Trust (2012)
	European Union Energy Performance of Buildings Directive (2012)		Non-state actors promoting approaches going beyond policy requirements, yet very few trial projects meeting UK zero carbon homes standards.	
2015–2016 U-turn in government low-energy buildings policy and curtailing on-the-ground activity	Vote for the UK to leave European Union (2016)	New conservative government (2015) cut down a dozen policies addressing building energy efficiency and renewable energy, including the removal of the Zero Carbon Homes target (2015). Later, energy efficiency policy, becomes part of new Department for Business, Enterprise and Industrial Strategy (2016), when the Department of Energy and Climate Change and is removed.	Non-government activities to actively lobby to reintroduce low-energy buildings policy.	- EEDO is abolished (2015) - ZCH is abolished (2016)
			New business models of energy retrofits gain attention, particularly Dutch initiated Energisprong operating as a partnership of housing associations, construction companies, trade bodies, and foundations.	

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